

# Assessment for Electrical Engineering Programs: Processes Implemented at the United States Air Force Academy

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**Abstract**—This article describes how the assessment process has been developed at the U.S. Air Force Academy. A major objective of the process design was to minimize additions to the steady state faculty workload. Since the academic program at this institution is similar to civilian universities, it is believed that the methods and results discussed can help other schools.

**Index Terms**—Assessment, engineering assessment, ABET, accreditation

## I. INTRODUCTION

ASSESSMENT is certainly a hot topic among electrical engineering faculty today. The recent emphasis on incorporating continuous process improvement into higher education in the United States has been a cause of concern for some faculties [1–5]. These faculty members often perceive that the effort required for assessment is more than they can accomplish in addition to all their other responsibilities. This paper reports on the processes developed and currently used at the United States Air Force Academy for assessment at the institutional, faculty, department, program, and course levels. While the definition of the assessment processes is not fully completed, it is hoped that this paper will help others reap the benefits enjoyed so far at this institution. Despite some initial trepidation, the defining and documenting of a multifaceted assessment plan which results in continuous process improvement—without significantly increasing the faculty workload—is well under way.

Section III reviews the processes through which the goals and objectives for the faculty, department, and courses were developed. Section IV describes the course assessment process as embodied in a Course Assessment Plan. Finally, near-term plans and some conclusions based on our experiences are presented.

## II. INSTITUTIONAL PROCESS

The United States Air Force Academy (USAFA) has always had a specific and unique mission: to produce the best possible second lieutenants for the United States Air Force. While this differs from the mission of other universities, the academic program is similar to many other

post-secondary institutions. Thus, the following discussion is widely applicable to a variety of schools.

Despite USAFA's well-defined mission, the evolving emphasis on defining higher education as a *process* that can be continuously improved through assessment has led the USAFA faculty to reexamine virtually all aspects of its operation. The initial focus was to prepare for a regional accreditation visit by the North Central Association in the spring of 1999. For the longer term, the engineering departments needed to create process improvement programs to meet the new engineering program accreditation criteria published by the Engineering Accreditation Commission of the Accreditation Board for Engineering Technology (ABET) [6].

Since USAFA was established in 1954, the faculty has had a strong tradition of self-examination and continuous improvement. Historically, the focus has been mainly on individual courses. However, the Faculty Curriculum Committee has periodically undertaken major reviews of the curriculum wherein the extensive general education core curriculum was examined in detail regarding appropriate discipline emphasis, integration of the learning experience, and student workload. These broader assessment efforts sought to achieve an optimum balance in terms of cadet (student) time, number of courses, enrollments, faculty headcount, and the mission.

To further ensure faculty efforts were properly coordinated and supportive of the Academy's mission, the most senior academic administrators met throughout academic year 1992–1993 and reached consensus on seven educational outcomes expected of the academic experience at the USAFA [7]. Although these are called the "Faculty Educational Outcomes," they are equivalent to the ABET Educational Objectives, as they describe the desired characteristics of our graduates after graduation [8]. The Academy vision statement and the Faculty Educational Outcomes are listed below.

- **United States Air Force Academy Vision:**<sup>1</sup> to be *Recognized worldwide as the premier developer of aerospace officers... leaders with impeccable character and essential knowledge... prepared and motivated to lead our Air Force and nation.*
- **Dean of Faculty Educational Outcomes:**

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<sup>1</sup> All graduates of the Academy receive commissions in the armed forces of the United States or of their native country.

- Officers who possess breadth of integrated, fundamental knowledge in the basic sciences, engineering, humanities, and social sciences; and depth of knowledge in an area of concentration of their choice.
- Officers who are intellectually curious.
- Officers who can communicate effectively.
- Officers who can frame and resolve ill-defined problems.
- Officers who can work effectively with others.
- Officers who are independent learners.
- Officers who can apply their knowledge and skills to the unique tasks of the military profession.

In the summer of 1994 an Educational Outcomes Assessment Working Group was formed. Initially comprised of 20 faculty volunteers, the group eventually involved over 50 faculty and students. They assessed the contributions of each of 35 required core courses to the achievement of the first, second, and fourth Faculty Educational Outcomes listed above [9]. Following this institutional lead, the Department of Electrical Engineering as well as the other academic departments developed their own self-assessment programs.

### III. DEPARTMENT OF ELECTRICAL ENGINEERING PROCESS

#### A. Initial Self Assessment

The first Electrical Engineering departmental self-assessment included a process to assess the department's success in achieving its goals and to evaluate the process itself. The process had three threads: one for the development and delivery of the curriculum, a second for recruitment and development of faculty and staff, and a third for providing the resources (equipment, parts, computing environment, etc.) necessary for the other two threads to be successful [10]. By December of 1997, the department senior faculty had concluded that the initial efforts at self-assessment had provided significant benefit but did not result in a sustainable process. Analysis indicated three areas should be addressed:

- improve the clarity of the department vision or mission statement (beyond the general intent to support the attainment of the Faculty Educational Outcomes),
- ensure complete and more narrowly focused goals to support the three process threads, and
- improve the precision in stating measurable objectives to support the goals.

Consequently, the department embarked on a systematic review of their assessment process in the fall of 1998. Senior department faculty members developed a draft vision or mission statement that was then distributed for review prior to discussion and revision in a department-wide meeting. There was a desire to keep the mission statement succinct. But the department has a diverse mission: responsibility for a core course taken by every single graduate (approximately 1,000 cadets each year), for all EE courses associated with the electrical engineering major, and for all EE courses associated with the computer engineering major (a program jointly administered with the

Department of Computer Science). After much discussion, a brief mission statement that covered these three responsibilities was agreed upon:

- To produce graduates motivated and able to excel as officers in a technologically sophisticated Air Force.

#### B. Goals

The next step taken was to draft, review, and discuss the department goals. After several iterations, which took the better part of the fall 1998 semester, the department members agreed upon four curricular goals: one to support the Faculty Educational Outcomes (which was later absorbed into the other three), one for the core offering and one for each of the two academic majors. Since the rest of this paper discusses the electrical engineering assessment process, only the electrical engineering curricular goal will be presented, along with the goals we developed for EE faculty and resources:

*EE Curricular Goal:* Contribute appropriately to the Dean of the Faculty Educational Outcomes by effectively delivering an Air Force relevant, stimulating, and nationally accredited degree program by which graduates achieve a foundation in electrical engineering of appropriate breadth and depth; the skills to tackle any electrical engineering task they encounter; and the intellectual curiosity to continue to add to their knowledge as officers in the Air Force.

*EE Faculty Goal:* Recruit, develop, and enrich faculty and staff of the highest caliber.

*EE Resources Goal:* Acquire and maintain required budget, facilities, and equipment to meet our mission.

Note that while goals express the desired result, they must be supported by realistically measurable objectives.

#### C. Objectives

Initially, measurable objectives were developed for each of the department goals. There were 13 objectives supporting the Faculty Educational Outcomes. In addition, there were three objectives specific to the electrical engineering core course as well as seven for each of the majors. Nine objectives supported the faculty and staff goal and five objectives were defined to measure the necessary resource support. Success criteria were defined for each of the objectives supporting the latter two goals.

As the department worked through this process to define our mission, goals, and objectives a recurring and often expressed concern was that this "assessment process" must not add significantly to the faculty workload. This concern was addressed in a meeting of the senior faculty. After a lively discussion about how the newly defined objectives were to be measured, it was decided that the traditional emphasis on course assessment could provide most assessment data. The Fundamentals of Engineering exam, student and graduate surveys, student writing samples, supervisor surveys, and an external advisory council were identified as necessary to supplement the course data. Subsequently, each faculty member in charge of a course (the Course Director) was asked to dust off the course goals

and objectives, review them, and amend them as necessary to support the electrical engineering program objectives. It was emphasized that objectives *had to be measurable*. Senior faculty members helped review each course's goals and objectives to ensure they were easily understood and as concise as possible, that the objectives were truly measurable, and that the objectives were necessary and sufficient to achieve the course goals. Foremost in the minds of the faculty was the fact that the Engineering Criteria 2000 requires accurate, reliable data on all aspects of program performance. After several iterations, each of the EE courses was defined in terms of easily understood goals and objectives. The objectives allowed, with minimal overhead, accurate measurement during the delivery of the course. During this iterative process, significant clarification of course objectives and integration of course topics with other department courses occurred. This certainly convinced the faculty participants of the value of better defining goals and objectives. This activity was concluded by the middle of the spring 1999 semester.

Since a process is not repeatable unless it is documented, the next step was to ask for volunteers to document a Course Assessment Plan (CAP) for their course that would describe in some detail exactly how each of the course objectives would be measured. Building from USAFA's historical emphasis on course assessment, this actually proved to be quite easy.

#### D. Course Assessment Plan

The Course Assessment Plan is typically two pages or less and contains only four sections. The first section presents the course goals and the second lists the objectives. Next is a matrix which maps the assessment methods to the objectives. These methods include exams, laboratory exercises, computer exercises, lab reports, lab notebooks, quizzes, and surveys. The matrix clearly shows the purpose of each activity and highlights objectives with little or no current method of evaluation. The matrix also helps uncover activities that do not directly support the objectives of the course. With the limited time in a semester and so much material to cover, Course Directors must make tough decisions about the wisdom of retaining any activities that don't directly support the course objectives. The last section of the CAP contains assessment method details such as duration, schedule, number of events (e.g. exams or quizzes), and the success criteria. The latter is critical to the assessment process. For example, to support measurement of a student writing objective, the Course Director could decide to assign writing skills grades on a lab notebook and set the success criteria at an average grade greater than 80%. Separate grades would be maintained on the students' writing skills; if the average fell below 80%, the instructors would be required to determine how to improve the students' writing skills. The next Course Director would be required to address this issue in a course brief before the course is run again.

This process was first used for only three courses as a test run, as discussed below. Once the three pilot CAPs were

refined, they were distributed to all department course directors as examples. CAPs were completed by the end of the spring semester for all courses to be offered in the fall of 1999. The CAPs have become an essential part of the delivery and assessment process for each course.

### IV. COURSE ASSESSMENT PROCESS

The overall course assessment process has three major facets: course briefs before the semester starts, running the course throughout the semester, and course reports at the end of the semester. The Course Assessment Plan (CAP) discussed above is an integral part of each step as depicted in Figure 1.

#### A. Course Briefs

Before the semester begins, each Course Director presents a course brief to the entire department. In addition to the administrative details of the course (text, number of students, topics, etc.), the Course Director must address all concerns and recommendations from the previous offering, which were recorded and archived in the end of course report. Any major changes to details such as textbook selection, major topics to be covered, and course objectives, must have prior approval from the Department Curriculum Committee. Course Directors also present to the department the current CAP as described above.

#### B. Course Log

Throughout the semester, Course Directors maintain a course log to record how the course progresses. Entries may be made on the pace of the course, timing of assignments, instructor and cadet feedback on major activities, problem areas in laboratories, explanations for unusual occurrences (e.g. higher than average time required for cadets to complete labs), and data from the activities listed in the CAP (e.g. exam averages, time log summaries, observations on cadet participation etc.). As each activity is completed, the Course Director refers to the CAP to ensure the data collected will be sufficient to determine if the supported objectives are sufficiently measured. If the objectives are not correctly measured or it appears one may not be achieved, minor course corrections can be made immediately.

#### C. Course Report

The End-of-Course Report is submitted after final grades are posted. It contains summary statistics (number of students, major activities, and grade distribution), a discussion summarizing course log entries, how objectives were met, and recommendations for the next offering. Recommendations must include assessment criteria to assist the next Course Director (who may or may not be the same person) in modifying the CAP if needed.

#### D. A Test Run

This process was initially tested with three different types of electrical engineering courses (a survey course taken by all non-technical majors, an introductory circuit analysis course, and a laboratory intensive course). Each

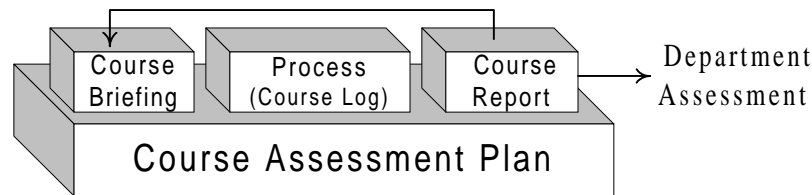


Fig. 1. The entire cycle of course assessment is based upon the Course Assessment Plan.

employed different metrics and activities. The CAP was invaluable in each case. The thought that went into construction of the CAP and the clear expression in the CAP of the role of exams in assessing achievement of course objectives had a positive impact. Exams were carefully constructed so that grades on individual problems could be directly used to measure objectives. When overall student performance was poor on a problem this was a warning that something was amiss. Remedial actions by faculty and reassessment via the next exam or final ensured the objective was met. Labs, demonstrations, and brief reports were incorporated to allow cadets more opportunities to show that they had mastered the knowledge and skills required of the objectives. Some specific examples follow of the positive impact developing a CAP had on our department.

- The course director (CD) for one of our lab courses discovered 3–5 lessons were being devoted to formal lab reports, although the CAP for that particular course consciously did not include writing skills as an objective. The CD developed “quick report templates” which shortened the time students spent writing, and allowed increased time they could devote to the technical content.
- The CAP for an introductory EE course allowed the CD to refine objectives in the syllabus and give students clearer guidance on expectations for particular assignments. Student feedback in Spring 1999 indicated they were better able to plan their study time and felt more confident as they completed assignments.
- Four new faculty members teaching an introductory EE course in Fall 1999 reported that the CAP helped them see immediately what topics they needed to focus on in class, and guided them in preparing quizzes and assigning homework problems.

#### E. Full Implementation

All courses now have goals and objectives that are briefed to the entire department faculty, included in the syllabus for discussion with cadets, and documented in the Course Assessment Plan. Course content and all activities are mapped to these objectives to ensure sufficient data is collected to ascertain how well each course met its objectives. Using the course log to collect data and impressions of the instructors enables the Course Director to produce more detailed course reports than previous semesters and provides a closed loop process so that previous recommen-

dations are always addressed. This is especially valuable for new Course Directors.

Through the course briefings, the course assessment process involves instructors, course directors, and senior administrators as well as instructors not currently teaching the course. This ensures that the full intellectual capacity of the department is brought to bear on efforts to improve each course each semester. Although the course briefs take the better part of a day, the participation by the faculty has shown their commitment to assessment and improvement of our processes. The CAP provides a valuable framework for assessment of a course from the planning stage to the reporting and improvement stage.

#### V. NEXT STEPS TO BE TAKEN

While the Department of Electrical Engineering at the USAFA has a long tradition of course assessment and improvement, the current effort to better define educational objectives and outcomes integrated with a department assessment process for the electrical engineering program has had a very positive impact. Indeed, the emphasis on institutionalizing a continuous process improvement has led to significant thought and discussion to ensure that the department “gets it right the first time.” Thus, while refinements continue on our course delivery and assessment processes, the department goals are also being re-examined. The conclusion was reached that the goal to support the Faculty Educational Objectives was actually redundant to the goals for the core course and each of our two programs; that department goal has now been eliminated. While this may seem as if the department is falling victim to the engineering syndrome of spending “90% of the time on the last 10% of the design,” there is a conscious effort to not do so. Eliminating a redundant goal means less work to show it is being met, and is explicit recognition that this is a continuous process improvement effort.

This semester each course director will refine the associated CAP as the semester progresses. Together, the department will examine the best ways to collect and store the assessment data. The objectives are to ensure the data can be easily entered (hopefully as part of the grade determination process), is accurate, reliable, and easily retrieved for analysis at the end of the semester for the course report (and later for longitudinal studies).

Matrices are also being developed for the overall electrical engineering program to show how individual course objectives support the program objectives, how the program objectives support the Faculty Educational Outcomes, and

how the program objectives support the ABET Engineering Criteria 2000 program outcomes criteria. As each course contributes to these matrices and the results are accumulated at the program level, it will be straightforward to show that all the program objectives have been covered, or to readily see where there are shortcomings.

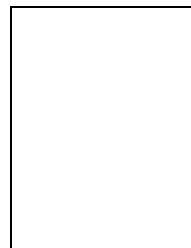
The last step will be to document the plan for the entire department assessment process through flow diagrams, templates, and text. Included in the department plan will be sub-plans that cover the electrical engineering program, the computer engineering program, the core offerings, faculty and staff development, and resources.

## VI. CONCLUSION

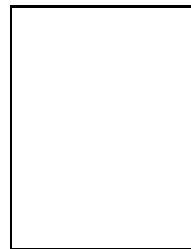
The assessment required by ABET 2000 is still a fairly new idea for most electrical engineering faculty today, and has been met with resistance and apprehension at many universities. This paper has shown that it is possible to create and implement a satisfactory assessment process which not only meets the needs of ABET 2000 accreditation, but also strives to minimize any additional work required of the faculty once steady state conditions are achieved. It is sincerely hoped that this discussion not only helps alleviate anxiety about starting an assessment program, but also provides a potential roadmap for other institutions to create and implement an assessment program which meets their own particular needs.

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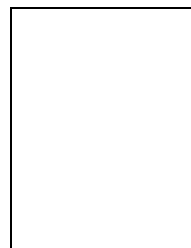
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